# Life-Cycle Cost Methodology

*2013 California Building Energy Efficiency Standards*

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# Introduction

The Warren-Alquist Act, requires the Energy Commission to develop and maintain energy efficiency standards that are "*… cost effective, when taken in their entirety, and when amortized over the economic life of the structure when compared with historic practice*".[1] This document describes the life-cycle cost (LCC) methodology to be used to evaluate proposed changes for the 2013 Building Energy Efficiency Standards. Cost effectiveness analysis is needed only for mandatory measures and prescriptive requirements. It is not required for compliance options.

With the 2005 update to the energy efficiency standards, the California Energy Commission moved to Time Dependent Valuation (TDV) of energy, which gives greater weight to energy saved during peak periods – or periods when the generation capacity is at its limit and when the distribution system is near capacity. The life-cycle cost approach to be used with the 2013 Standards also will be based on TDV energy. The weight assigned to energy consumption depends on climate zone, time of use, building type (residential or nonresidential) and fuel type (electricity, natural gas, or propane).

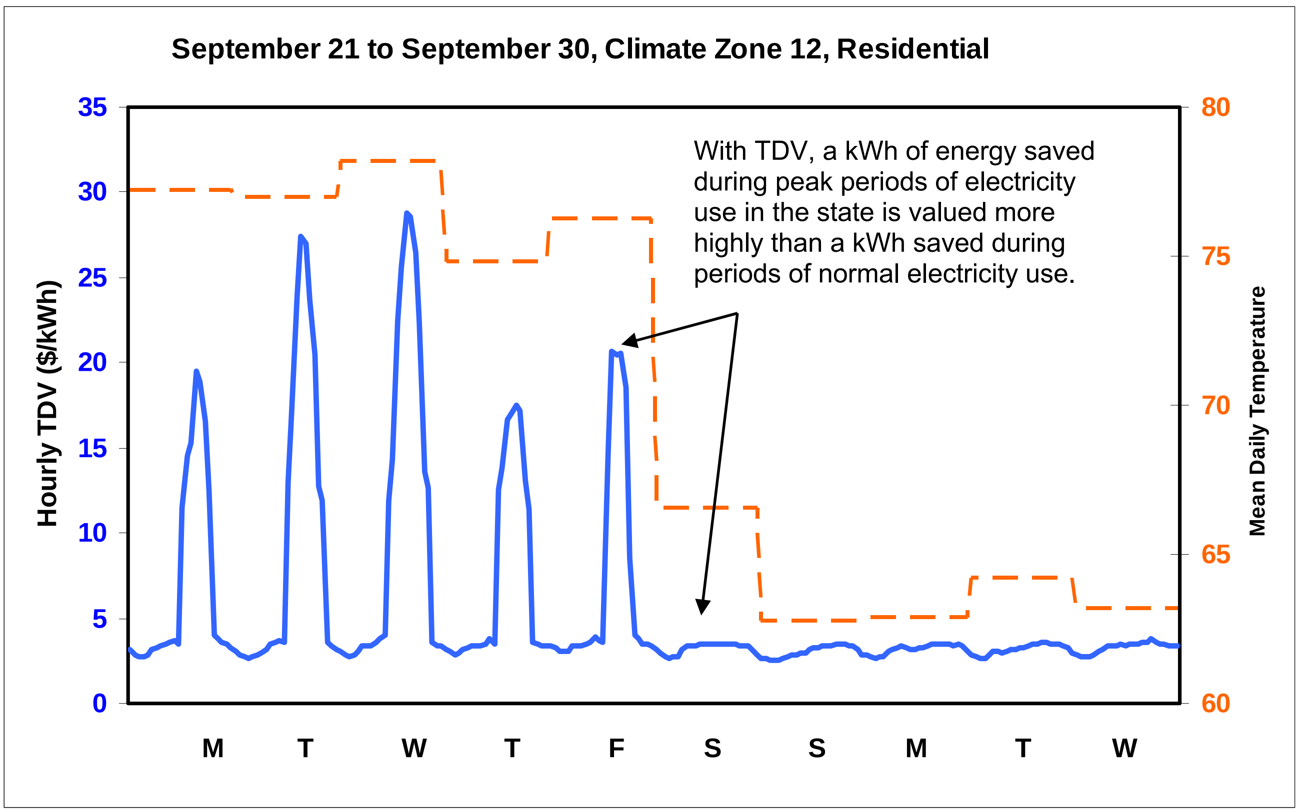


*Figure 1 – Sample 2013 TDV Values*

[1] Warren Alquist Act, Public Resources Code Section 25402.

# Methodology for Developing 2013 TDV Curves

For the 2013 Standards, new TDV curves have been developed to reflect updated electricity, natural gas, and propane cost forecasts. The new 2013 TDV curves can be found at: http://www.ethree.com/public_projects/2013_Title24.html . Cost-effectiveness analyses will use these new TDV curves to determine the cost savings associated with efficiency measures.

TDV numbers are initially developed in terms of hourly values, in dollars, for a given unit of site energy consumption ($/kWh or $/therm). Average TDV values (unweighted) across all climate zones and hours of the year are given in Table 1:

*Table 1 – Average Cost of Site Energy for Natural Gas and Electricity, 2008 to 2013*

| **30 Year Residential** | 2008 | **2013** | 2013/2008 |
|---|---|---|---|
| Natural Gas (NPV$/therm) | $24.32 | **$27.68** | 114% |
| Electricity (NPV$/kWh) | $2.33 | **$3.62** | 156% |

| **15 Year Nonresidential** | 2008 | **2013** | 2013/2008 |
|---|---|---|---|
| Natural Gas (NPV$/therm) | $12.72 | **$14.59** | 115% |
| Electricity (NPV$/kWh) | $1.63 | **$1.85** | 113% |

| **30 Year Nonresidential** | 2008 | **2013** | 2013/2008 |
|---|---|---|---|
| Natural Gas (NPV$/therm) | $23.97 | **$25.96** | 108% |
| Electricity (NPV$/kWh) | $2.66 | **$3.36** | 127% |

Note: Source file for 2013 data is the 2011v3 TDV dataset

The 2013 TDV development process is largely the same as the approach taken for 2008, but updated with more current projections of energy costs. The TDV values are developed for the 15 year or 30 year nonresidential analysis periods and for a 30 year residential analysis period. Forecasts of commodity costs and rates over these time periods were used to project the future costs, and the present value was determined by applying a 3% real (inflation adjusted) discount rate.

While the TDV values are initially calculated in terms of cost, TDV values are presented in the Standards and in the modeling tools in terms of energy units (kBtu/kWh or kBtu/therm) for the following reasons:

- Describing TDV in terms of energy units is consistent with past performance compliance methods. The intent is to minimize the impact of TDV on practitioners. The proposed design would still need to use less energy than the standard design; TDV energy simply is substituted for source energy and the absolute value is similar.
- If Title 24 instead used dollars as the currency for compliance it would imply that the building owner's energy costs should be equal to this amount over the period of analysis. Given that local utility rates may vary and actual building operating assumptions are likely to be different, it was not desirable to imply that the TDV savings are the same as the dollar savings that any single building owner might realize.

Converting the TDV dollar values into energy units follows the precedent used for traditional source energy metrics. The base energy unit for source energy is natural gas. Likewise, the base energy unit for TDV is based on the forecasted cost of natural gas (the forecasted, usage weighted average cost of natural gas across the entire state for each customer class).

The adjustment factors listed in Table 2 are used to convert the initial $/kWh or $/therm TDV numbers to kBtu/kWh or kBtu/therm TDV numbers. The adjustment factors are derived from the net present value of the cost of natural gas in 2005 but corrected for inflation to 2011 dollars. Note that although the Standards will be adopted in 2013, all economic analysis is being conducted in 2011 dollars because that is when the cost effectiveness analyses for the Standards will be completed. The 2013 adjustment factors are derived from the 2005 adjustment factors, rather than being calculated entirely anew, to maintain comparability in modeled results with respect to the total TDV kBtu energy use of a building. The results of that conversion to 2011 dollars can be found in Table 2.

*Table 2 – Statewide TDV Net Present Value 2011$/kBtu (All Fuel Types)*

| Building Type | 30-year ($/TDV kBtu) | 15-year ($/TDV kBtu) |
|---|---|---|
| Low-Rise Residential | $0.1732 | n.a. |
| Nonresidential & High-rise Residential | $0.1540 | $0. 08900 |

The equation below, by example, provides the units analysis for electricity TDV to move from the $/kWh to TDV kBtu/kWh. The "TDV energy factors" are the source energy values referenced in the Title 24 regulations and used in the compliance calculation process to produce a TDV kBtu energy use estimate for a modeled building:

$$\text{TDV Energy Factors} = \frac{\text{TDV Dollars}\left[\text{NPV\$/kWh}\right]}{\text{Forecasted NG Cost}\left[\text{NPV\$/kBtu}\right]} = \frac{\frac{\text{NPV\$(hr)}}{\text{kWh}}}{\frac{\text{NPV\$}}{\text{kBtu}}} = \frac{\text{kBtu(hr)}}{\text{kWh}} \textit{ or } \frac{\text{TDV kBtu}}{\text{kWh}}$$

Just like TDV dollar values, the TDV energy factors vary for each hour of the year. To evaluate the TDV energy cost or benefit of a measure, each hour's electricity savings is multiplied by that hour's TDV energy value. As shown below, this yields an annual savings figure in terms of TDV kBtu.

$$\text{Annual TDV Savings}\left[\text{TDV kBtu}\right] = \sum_{h=1}^{8,760} \text{Energy Savings}_h \left[\text{kWh}\right] \times \text{TDV Energy Factor}_h \left[\frac{\text{TDV kBtu}}{\text{kWh}}\right]$$

For evaluating the cost-effectiveness of new measures, the annual TDV kBtu energy savings calculated by an energy model can be multiplied by the $/kBtu adjustment factors listed in Table 2.

Unlike the original 2005 TDV values, the cost of environmental externalities are now included in the standard TDV values.

# Methodology for Analyzing Life-Cycle Cost

If a measure reduces overall life-cycle cost from the current basecase then it is cost-effective. It is often not necessary to calculate absolute life-cycle cost. The change in life-cycle cost from the basecase is given in the following equation. If the change in life-cycle cost is negative then the measure is cost-effective. Negative change in life-cycle cost means that the present value of TDV energy savings is greater than the initial cost premium, i.e. the proposed measure reduces the total life cycle cost as compared to the base case.

$$\Delta LCC = \text{Cost Premium} - \text{Present Value of Energy Savings}^{2}$$

$$\Delta LCC = \Delta C - (PV_{TDV\text{-}E} * \Delta TDV_{E} + PV_{TDV\text{-}G} * \Delta TDV_{G})$$

Where:

| | |
|---|---|
| $\Delta LCC$ | change in life-cycle cost |
| $\Delta C$ | cost premium associated with the measure, relative to the basecase |
| $PV_{TDV\text{-}E}$ | present value of a TDV unit of electricity |
| $PV_{TDV\text{-}G}$ | present value of a TDV unit of gas |
| $\Delta TDV_{E}$ | TDV of electricity |
| $\Delta TDV_{G}$ | TDV of gas |

Propane TDV costs are not used in the evaluation of energy efficiency measures.

### Time Period of Analysis

All low-rise residential measures shall be evaluated over a period of 30 years. Nonresidential building envelope measures shall also be evaluated over a period of 30 years; however, nonresidential lighting, HVAC and water heating measures shall be evaluated over a period of 15 years. Values from Table 2 should be selected accordingly and used with the appropriate TDV dataset.

Measure costs and benefits shall be estimated in 2011 dollars.

### Maintenance and Replacement Costs

Sometimes, a measure will have different maintenance or replacement costs as compared to the basecase. When this occurs, the cost premium should discount all future costs to present value at a discount rate of 3%. The initial cost of both the measure and basecase should include costs that are expected to occur over the assumed life of the measure (see section above on Period of Analysis).

### Definition of Basecase

The basecase for the analysis of each measure is the 2008 Title 24 Building Energy Efficiency Standards.

### Measure Information Template

Further information on the life cycle cost methodology used to evaluate proposed energy efficiency measures can be found in the Energy Commission's *Measure Information Template*. The *Measure Information Template* also lists the necessary reporting requirements to document proposed changes to the code.

[2] The Commission uses a 3% discount rate for determining present values for Standards purposes.

### Continuous Measures

Some energy efficiency measures have continuous levels. Insulation is an example. The approach expected to be used for determining the life-cycle cost choice for continuous measures is to search for the level of the measure that reduces life-cycle cost the most, relative to the basecase. This is comparable to ranking the measures by energy saving potential and showing that each incremental change is cost effective relative to the previous measure. The Commission may, as it deems appropriate, select measures for inclusion that are shown to be cost effective but which do not have the lowest life cycle cost among the alternatives that are evaluated.